

## SPECIFICATION

### PUSH-BUTTON SWITCH MEMBER AND MANUFACTURING METHOD OF SAME

#### Field of The Invention

The present invention relates to a member for constituting or forming a push-button switch (called hereinlater "push-button switch member") and a method of manufacturing such push-button switch member, the push-button switch being provided with a display section displaying a switching function in an input device such as cellular phone (portable phone), portable terminal such as PDA (Personal Digital Assistant), car-stereo, board computer mounted to vehicle, audio-set, measurement instrument, personal computer, etc., and more particularly, being applicable to the push-button switch of a back-light type switch capable of lightening up the display section even in a dark place.

#### Background Technology

In prior art, for a member for push-button switch utilized for the input device of the kind mentioned above, it is said to be necessary to have a letter back-lightening function for back-lightening a display section showing a push-button switching function in a night use.

For example, with reference to Fig. 18 or 19, showing

a sectional view of a member for a push-button switch 30 utilized for an input device of a cellular phone, the push-button switch 30 comprises cover base member 32 having a plurality of key top portions 31 each constituting an operation key and a circuit board (substrate) 33 disposed so as to oppose to the cover base member 32. These cover base member 32 and the circuit board 33 are assembled, in the opposing state, in a housing of an input device as an object device so as to achieve a switching function. Furthermore, in order to make clear the function of the push-button switch 30 even in a dark place, top surface portions or rear surface portions of the respective key top portions 31, each constituting the operation key, are provided with display sections 34 to which letters, symbols, figures or like are described so that a direct light, from a light source such as an LED 35 or an electric bulb 36 disposed on the circuit board 33, or a reflected light generated by reflecting such direct light to peripheral members or like transmits from the rear surface portion of the key top portion 31 to the top surface portion thereof to thereby visually recognize a content displayed on the display section 34 in the light-up manner. Accordingly, even in night time, the cellular phone or like can be used with out any problem.

Furthermore, in a case where more even brightness is needed, as shown in Fig. 20 or 21, it has been attempted to enlarge a luminescent surface area by inserting a light

guide member 37 of thin plate shape between the LED 35 and the key top portion 31 or using an EL (electro-luminescence) sheet 38 performing surface-luminescence (emission) as a light source.

However, the light source such as LED 35, electric bulb 36 and EL sheet 38 and the light guide member 37 guiding the direct light from the light source are arranged to portions apart from the key top portions 31 in order not to obstruct contacting function of contact portions 39 on the circuit board 33 to the key top portions 31. Accordingly, it is obliged for the light sources 35, 36 and 38 and the light guide member 37 to take a positional relationship apart from the display sections 34, and in order to obviate such defect, the LED 35, the electric bulb 36 and the light guide member 37 are increased in numbers to be arranged and expensive EL sheets 38 are used. In such case, a design of a push-button switch is made difficult because of increased number of parts or elements to be arranged, and in an adverse case, nevertheless, sufficient light amount cannot be ensured for recognizing the displayed contents on the display sections 34 in dark place, thus being not so practical.

Especially, in general, for the cellular phone operated by a cell, which requires small power consumption, it is also required to ensure a sufficient amount of light with reduced number of light sources. However, in the

conventional method mentioned above, mere portion of the light generated from the light source can be contributed to visually recognize the display section 34, and even in a large power consumption, the ability of the visual recognition could not be improved, thus being conflictive

In addition, it is difficult to make the thickness of the push-button switch 30 thinner because the light sources 35, 36, 38 and the light guide members 37 are disposed between the key top portions 31 and the contact portions 39 arranged on the circuit board 33 opposing to the key top portions 31, which results in restriction for making the thickness of the input device or machinery body thinner, as well as results in increase in weight.

In order to obviate such defects, there is known prior art technology such as disclosed in Japanese Patent Laid-open (KOKAI) Publication No. 232954/1999 or No. 285760/2000, in which it is attempted to prevent the light dispersion and the light quantity loss due to the location of an obstacle by attaching a light source to a portion near a display section with an area (plane or flat) emitter spontaneously emitting a light to a top surface portion of the key top portion.

Such area emitter is one formed by forming a transparent conductive layer on a transparent insulating film through ion-sputtering of ceramic such as tin oxide, tin indium oxide, antimony tin oxide or like or one formed

by forming a transparent conductive ink on the transparent insulating film, through a screen printing method, in which ceramic powder is dispersed in and mixed with a transparent insulating resin.

However, in the method in which the transparent conductive layer is formed with the ceramic layer by utilizing the ion spattering method using tin oxide or like, the ceramic layer is itself brittle and is not almost extendable, so that even if a transparent insulating film is elongated so as to have a desired key top shape, the transparent conductive layer does not follow such shape and a resistance rapidly increases, thus being inconvenient.

Furthermore, in the prior art method in which the transparent conductive layer is formed through the printing method using the transparent conductive ink formed by adding the ceramic powder into the transparent insulating resin and then mixed therewith, the conductivity is maintained by linkage of the powder. However, in this method, the resistance is not reduced so remarkably even with much amount of ceramic powder content, and it is difficult to uniformly disperse the ceramic powder. Accordingly, at a time when it is desired to elongate to deform the transparent insulating film as a base material so as to provide a desired shape, the linkage of the ceramic powder of the transparent conductive layer is easily destroyed, resulting in increasing of resistance and, hence, causing of

uneven luminance.

Then, the present invention has been conceived to solve such problems mentioned above encountered to a member for a push-button switch back-lightening a display section of a key-top portion of a conventional structure and has an object to provide a member for constituting a push-button switch having a thin thickness and high visual recognition performance and capable of realizing back-lightening of a display section having high light emission efficiency with reduced consumption of electric power and less uneven luminance by using the back-lightening of the display section with out any loss of light energy.

#### Disclosure of The Invention

The first invention is, for solving the above problems, to provide a push-button switch member which comprises a key-top portion for pressing a movable contact point disposed so as to oppose to a stationary contact point on a circuit board against the stationary contact point, and a cover base member provided with the key top portion at a predetermined portion thereof and mounted to the circuit board, the key-top portion being provided with a display section displaying a switching function and a area emitter member integrally formed with the display section, wherein the area emitter member is provided with a light emitting layer disposed between a base electrode and a transparent

electrode disposed so as to oppose to the base electrode and the transparent electrode is arranged to be contacted to the display section and made from a transparent conductive polymer.

According to this invention, since the display section itself emits a light, the visibility of the key-top portion can be remarkably improved.

In addition, since the light emitting layer of the area emitting member is used only to the key-top portion, the manufacturing cost can be reduced and the power consumption for back-lightening can be also reduced. Furthermore, it is not necessary to dispose a light source or light guide member between the key-top portion and the contact point formed to the circuit board so as to correspond to the key-top portions, so that the push-button switch member having thin thickness can be provided. Therefore, an input device or machinery incorporated with such push-button switch member can be made thin.

The second invention is, in addition to the structure of the first invention, characterized in that the transparent electrode has a surface resistance of not less than  $10\Omega/\square$  and light permeability of not more than 90%.

According to this invention, the power consumption can be made reduced while keeping the transparency and the extendability.

The third invention is, in addition to the structure

of the first or second invention, characterized in that the transparent electrode comprises an electro conductive fiber having a diameter of not more than  $0.5 \mu\text{m}$  and an aspect ratio of not less than 20.

According to this invention, even in the case where the tensile force due to the drawing process is applied, the transparency and the conductivity can be maintained, so that the reliability of the switching function can be further secured, in addition to the effects of claim 1 and 2.

The fourth invention is, in addition to the structure of any one of the first to third inventions, is characterized in that the transparent electrode is colored.

According to this invention, the display section constituting elements can be reduced in number, so that the manufacturing cost can be further reduced.

The fifth invention is, in addition to the structure of any one of the first to fourth inventions, is characterized in that the transparent conductive polymer is composed of one of the derivatives selected from the group consisting of polypyrrole, polythiophen and polyaniline.

The transparent conductive polymer material has strong resistance to oxygen and humidity, and good transparency and conductivity, so that the visibility of the key-top portion and the reliability of the switching function can be further improved.

The sixth invention is, in addition to the structure



of any one of the first to fifth inventions, is characterized in that elongatable (extendable) conductive members are connected to the base electrode and the transparent electrode, respectively, and the conductive member, having an extendable portion to which tensile force is applied at a molding time is covered with an extendable insulating thin film.

According to this invention, the insulating thin film limits the flow of the material of the conductive member extending from the base electrode, so that the increase of the resistance of the base electrode can be suppressed and the display section emitting even light can be provided. In addition, since the small light emitting layer can be disposed near the display section, the good visibility in design is obtainable even with small consumption power. Furthermore, since another additional part or member is not required, the push-button switch member having thinner in thickness, smaller in size and more economical merit can be realized.

The seventh invention is, in addition to the structure of the sixth invention, is characterized in that the conductive members connected respectively to the base electrode and the transparent electrode are arranged so as not to be overlapped with each other.

According to this invention, no damage is caused by contacting of the base electrode with the transparent

electrode at the time of the molding process and in use of a completed product after the molding, thus achieving stable back-lightening.

The eighth invention is, in addition to the structure of the sixth or seventh invention, is characterized in that the insulating thin film has a storage modulus, at molding temperature thereof, which is larger than a storage modulus of the conductive members connected to the base electrode and the transparent electrode at the molding temperature thereof.

According to this invention, at the time of forming the shape of the key-top portion, the moldability can be improved.

The ninth invention is, in addition to the structure of any one of the sixth to eighth inventions, is characterized in that the base electrode and the conductive member connected to the base electrode are composed of a conductive layer containing organic polymer and conductive filler and the filler has at least one side length not more than  $1/3$  of thickness of the conductive layer.

According to this invention, since the interlocking of the conductive fillers can be maintained after the molding, the conductivity can be further ensured.

The tenth invention is, in addition to the structure of the ninth invention, is characterized in that a conductive polymer layer is further added to the conductive

layer.

According to this invention, the conductivity can be further ensured.

The eleventh invention is, in addition to the structure of the ninth or tenth invention, characterized in that the conductive filler is composed of a fiber material having a diameter of not more than  $1\mu\text{m}$ .

According to this invention, since the conductive filler can be easily orientated at the molding time, even if an excessive elongation more than 200% is applied, the required conductivity can be maintained.

The twelfth invention is, in addition to the structure of any one of the sixth to eleventh inventions, characterized in that the base electrode and the conductive member connected to the base electrode are formed of conductive polymer.

According to this invention, the excessive increase of the resistance due to the elongation is hardly caused and the molding yield will be readily stabilized.

The thirteenth invention is, in addition to the structure of any one of the first to twelfth inventions, characterized in that the key-top portion includes key-top body in shape of key-top formed to a rear surface of the base electrode, and a push projection is formed to the rear surface of the key-top body for contacting the movable electrode to the stationary electrode.

According to this invention, the push projection makes the movable contact point to surely contact the stationary contact point, so that the reliability of the switching function can be enhanced.

The fourteenth invention is, in addition to the structure of any one of the first to twelfth inventions, characterized in that the key-top portion has a transparent first resin molded form, having a key-top shape to the surface of the transparent electrode through transparent insulating film and a second resin molded form formed with a push projection to the rear surface of the base electrode for contacting the movable electrode to the stationary electrode.

According to this invention, the push projection makes the movable contact point to surely contact the stationary contact point, so that the reliability of the switching function can be enhanced.

The fifteenth invention is, in addition to the structure of any one of the first to twelfth inventions, characterized in that a plurality of switch circuits composed of a plurality of key-top portions and base electrodes and transparent electrodes corresponding to the key-top portions, respectively, are integrally formed to the cover base member.

According to this invention, since a plurality of key-top portions can be highly back-lightened evenly, when it is

applied to electric or electronic element or equipment requiring a plurality of key-top portions such as cellular phone, the design and usability can be improved.

The sixteenth invention is a production method of the push-button switch member recited in any one of the first to fifteenth inventions, which is characterized in that, at a time when a transparent insulating film, having one surface on which the transparent electrode is formed, is subjected to a drawing process so as to be formed in a predetermined key-top shape, the transparent electrode of the elongating portion at which tensile force is applied at the drawing process, is formed from elongatable conductive polymer.

According to this invention, any conductive defect due to the molding working is not caused, no defect at the side surface portion of the key-top portion due to the conductive defect is caused, thus improving the manufacturing efficiency.

The seventeenth invention is, in addition to the structure of the sixteenth invention, characterized in that at least the elongating portion of the transparent electrode before the drawing process is thickened.

According to this invention, since the conductivity at the elongating portion of the transparent electrode due to the molding working can be maintained, the conductive defect at the bent portion of the transparent electrode can be eliminated, thus improving the manufacturing efficiency.

The eighteenth invention is a production method of the push-button switch member recited in any one of the sixth to fifteenth inventions, which is characterized by comprising the steps of forming a transparent electrode at a portion corresponding to a key-top portion formed to one surface of a transparent insulating film covering an outer surface of the key-top portion, forming a light emitting layer on the transparent electrode, forming a base electrode on the light emitting layer, preparing a printed sheet before a drawing process for forming elongatable conductive members connected to the base electrode and the transparent electrode, and drawing the printed sheet so as to form a predetermined key top shape, wherein the elongating portion constituting a portion of the conductive member to which tensile force is applied at the drawing process is covered with an elongatable insulating thin film.

According to this invention, the insulating thin film limits the flow of material of the conductive member extending from the base electrode, so that the increase of the resistance of the base electrode can be suppressed and the display section emitting even light can be provided. In addition, since the small light emitting layer can be disposed near the display section, the good visibility in design is obtainable even with small power consumption. Furthermore, since another extra part or member is not required, manufacturing method of the push-button switch

member having thinner in thickness, smaller in size and more economical merit can be realized.

#### Brief Description of The Drawings

Fig. 1 is a sectional view showing an essential portion of a member for a push-button switch according to a first embodiment of the present invention.

Fig. 2 is a sectional view of an essential portion of a first example of a display section of the push-button switch member according to the present invention (of the first embodiment).

Fig. 3 is a sectional view of an essential portion of a second example of the display section.

Fig. 4 is a sectional view of an essential portion of a third example of a display section.

Fig. 5 is a sectional view of an essential portion of a fourth example of the display section.

Fig. 6 is a sectional view of an essential portion of a fifth example of the display section.

Fig. 7 is a sectional view of an essential portion of a sixth example of a display section.

Fig. 8 is a sectional view of an essential portion of a seventh example of the display section.

Fig. 9 is a sectional view of an essential portion of an eighth example of the display section.

Fig. 10 is a sectional view of an essential portion of

a ninth example of a display section.

Fig. 11 is a sectional view of an essential portion of a tenth example of the display section.

Fig. 12 is an enlarged sectional view showing an essential portion of a member for a push-button switch according to a second embodiment of the present invention having the structure shown in Fig. 3.

Fig. 13 is a plan view showing a base electrode of the push-button switch member of Fig. 12 and a conductive pattern continuous to the base electrode.

Fig. 14 is a plan view showing a transparent electrode of the push-button switch member of Fig. 12 and a conductive pattern continuous to the base electrode.

Fig. 15 is a plan view showing an overlap state in which the transparent electrode and the conductive pattern continuous thereto are overlapped with the base electrode of the push-button switch member and the conductive pattern continuous thereto.

Fig. 16 is an enlarged sectional view showing a structure, more in detail, of the base electrode in a design like the display section shown in Fig. 11.

Fig. 17 is a sectional view showing an essential portion of a member for a push-button switch according to a third embodiment of the present invention.

Fig. 18 is a sectional view of an essential portion of a push-button switch member utilizing an LED as a light



source of a conventional structure.

Fig. 19 is a sectional view of an essential portion of a push-button switch member utilizing a bulb as a light source of a conventional structure.

Fig. 20 is a sectional view of an essential portion of a push-button switch member utilizing a conventional light guide member.

Fig. 21 is a sectional view of an essential portion of a push-button switch member utilizing an EL sheet as a conventional light source.

#### Best Mode for Embodying The Invention

Respective embodiments according to the present invention will be described hereunder with reference to the accompanying drawings.

#### [First Embodiment of The Invention]

Fig. 1 is a sectional view showing an essential portion of a member for a push-button switch according to a first embodiment of the present invention.

A member 1 for constituting or forming a push-button switch (called hereinlater "push-button switch member") according to the first embodiment shown in Fig. 1 is provided with a key-top portion 3 and a display section 2 displayed with switching functions by means of letters, symbols, figures or like, the display section 2 being provided on a top (front) surface side of the key-top

portion 3 and utilizing an area (plane or flat) emitter 4 spontaneously emitting a light.

The push-button switch member 1 according to the first embodiment is provided with a movable contact point 7 disposed so as to oppose to a stationary contact point 6 formed on a circuit board 5. More in detail, the movable contact point 7 is formed to a front end of a push projection 8 formed to a central portion of a rear surface side of the key-top portion 3, and when the key-top portion 3 is pushed toward the circuit board 5 to thereby contact the movable contact point 7 to the stationary contact point 6.

Furthermore, a cover member (not shown) formed of an elastic material such as silicone rubber is disposed between the push-button switch member 1 and the circuit board 5 so as to cover an outer periphery of a plurality of key-top portions 3 disposed to predetermined positions, and when the key-top portion 3 is depressed, a portion of the cover member is elastically deformed towards the circuit board side and, on the contrary, when a hand (finger) of an operator is released from the key-top portion 3, it is returned to its original position by an elastic restoring force of the cover member.

The key-top portion 3 has a key-top body 16 which determines a substantial shape of the key-top portion 3, and a material for the key-top body 16 is selected from hard or

soft resin or elastomer, or the like material. Thermoplastic or thermosetting material is also usable, and a shape thereof is not limited to such as film shape, pellet shape or liquid state. However, it may be desired to use a liquid-state thermosetting resin because it is easily injected.

An outer peripheral portion of the key top portion 3 except the rear surface portion thereof is covered with a transparent insulating film 9, and to a rear surface of the transparent insulating film 9, there is formed a transparent electrode 10 constituting one electrode of the area emitter 4 in a range between the side surface of the key-top portion 3 and the top surface portion thereof. On the other hand, to the rear surface of the transparent electrode 10 and a rear surface portion of the transparent insulating film 9 at which the transparent electrode 10 is not formed, there is formed an opaque color layer 11 having a light-shielding property and insulation property. This opaque color layer 11 is formed with a punched-out portion or section 12 in conformity with the letter, symbol or figure formed to the display section 2. The opaque color layer 11 has a rear surface to which a light emitting layer 13 is formed so as to have a size slightly smaller than the top surface portion of the key-top portion 3 including the punched-out portion 12. Accordingly, the punched-out portion 12 is embedded with the light emitting layer 13 to thereby form a pattern section consisting of the letter, symbol or figure, and a

design of the display section 2 is completed by this pattern section and a base composed of a peripheral opaque color layer 11 of the punched-out portion 12. A base electrode 14 forming the other one of electrodes is provided for the rear surface of the light emitting layer 13.

The transparent insulating film 9 of the outer surface of the key-top portion 3 may be formed, so as to have a thickness of about 25 to 500  $\mu\text{m}$ , of a material selected from the followings: polyvinyl alcohol, polyethylene, polyethyleneterephthalate, polyethylenenaphthalate, polyacryl, polycarbonate, polystyrene, polyfrroethylenepropyrene, polychlorotrifluoroethylene, polyvinylidene, polyimide, poliamideimide, polyethersulfone, polysulfone, polyphenylenesulfide, polyamide, polyarylate; styrenic base, polyester base or polyamid base thermoplastic elastomers and copolymers thereof; modified materials such as alloy thereof; composite layer products formed by laminating several kinds of films; or like. In the present embodiment, it will be desirable to use a resin, which is suitable for easily forming the key-top portion 3 and which has a softening point of about 50 to 200°C, preferably 100 to 150°C and has a low gas permeability. After molding, it will be also desirable, for protecting the light emitting layer 13 and extending its life time, to form an inorganic oxide, as gas barrier layer, such as silicon dioxide or aluminum oxide to an outer surface thereof by means of vapor

deposition method or sol-gel process.

The conductive polymer utilized for the transparent electrode 10 are such as: polyacetylene, polyparaphenylene, polypyrrole, polythiophen, polyaniline, polyphenylenevinylene, polyselenophen, polyazulene, polypyrene, polycarbazole, polypyridazine, polynaphthylene, or polyfluorene; compounds, into which such substituents as alkyl or alkoxy group is introduced into the foregoing compounds, such as polyethylene-dioxythiophene, polythienylene-vinylene, poly (3-methylthiophene), poly(3,4-dimethylthiophene), poly (3-thiophene-  $\beta$  -ethansulphonate), polymethylpyrrole, poly (3-hexylpyrrole), poly (3-methyl-4-pyrrole carboxylic acid methylester), polycyanophenylenevinylene, polydimethoxyphenylenevinylene derivative; or conjugate conductive polymers such as polyisoprene modified substance.

In the above conductive polymers, it will be desirable to utilize derivatives of polypyrrole, polythiophen and polyaniline having good resistance to oxygen and humidity, good transparency and good conductivity in additional consideration of influence of dopant. In the case of an use to an organic EL, it will be desirable to use derivatives of polyaniline and polythiophen having a high work function as anode.

Since the conductive polymers have conjugate double bond, thus being rigid and poor in adhesion ability, it is

preferred to apply an anchor coat having high polarity in order to achieve a good adhesion to a base member. Polyurethane, polyamide, polyacrylamide or like, or polymer having, as side chain, amino group, hydroxyl group, nitrile group, carboxyl or cyano group can be preferably used as the anchor coat.

Furthermore, since conductive polymer itself does not show a desired resistance, it is necessary to carry out the doping. For this reason, there will be listed up, as acceptor, halogen such as iodine and bromine, Lewis acid such as  $\text{PF}_5$ ,  $\text{AsF}_5$  and  $\text{BF}_3$ , protonic acid such as  $\text{HF}$ ,  $\text{HCl}$ ,  $\text{H}_2\text{SO}_4$ , organic acid such as paratoluene sulfonic acid and paramethoxyethyltoluenesulfonic acid, transient metal compound such as  $\text{FeCl}_3$ ,  $\text{TiCl}_4$ , organic substance such as tetracyanodimethane, tetracyanotetraazaphthalene, chloranil, or alkali metal such as  $\text{Li}$ ,  $\text{Na}$  and  $\text{K}$  or alkali earth metal such as  $\text{Ca}$ ,  $\text{Sr}$ ,  $\text{Ba}$  as donor.

In order to increase stability against moisture and temperature, it is necessary to pay attention to dedoping. It is required to avoid use of electrolytic anion, cation or like. Coordinate bond or copolymerization with conductive polymer is an effective method for fixing. Especially, it is easy to introduce a dopant to dendrimer composed by sequentially bonding central core molecular with  $\text{AB}_2$ -type being a starting material, oligomer or polymer such as polystyrene, polymethylmethacrylate, polyurethane or

fullerene molecular, and to carry it as functional group, which is especially desired because of increased bonding property to the transparent insulating film 9. The dopant, which became multifunctional with a carrier being a center thereof, acts to bridge the conductive polymer molecules, to be stabilized and to decrease resistance, thus being extremely useful. In a sealed state of the conductive polymer, the influence of the dedoping becomes very small, so that it is better to accommodate the conductive polymer in a mold body. Moreover, in order to reduce the conductivity, it is effective to elongate the conductive polymer to thereby shorten a distance between the molecules of the conductive polymer and elongation at the time of the molding will be utilized.

At the time of drawing process, a tensile force is applied to, specifically, a portion (elongated portion) corresponding to a side surface of the key-top portion 3, so that it is necessary for the transparent insulating film 9 and the transparent electrode 10 to be formed from a material that is hardly broken or hardly increase in resistance will be selected as a material for the elongating portion. In this meaning, the conductive polymer is a suitable material. According to the molding process, specific resistance of the conductive polymer does not change, but a physical thickness is made thinner and the conductive polymer is elongated, thus increasing in its

resistance. For this reason, the conductive polymer disposed at a peripheral portion (elongated portion) of the pattern of the display section 2 having high elongating rate is formed to be thickened so as to suppress the absolute value of the resistance. In the case where the base portion of the display section 2 or side surface of the key-top portion 3 is opaque, it may be possible to compensate for the increasing of resistance by means of conductive ink, which will be described hereinafter.

In a case where an excessive elongation over 100% is made, there is a fear of increase in resistance. In such case, the conductivity will be maintained by mixing a fine conductive fiber having a diameter of not more than  $0.5\mu\text{m}$  to the conductive polymer. In case of the fiber diameter exceeding  $0.5\mu\text{m}$ , it is not substantially transparent and the fiber is made rigid, thus being not suitable for molding. An aspect ratio is desired to be more than 10, preferably, more than 20 or further preferably, more than 50, and in view point of printing, the length of less than 0.1 mm will be desired.

Still furthermore, in a case of an excessive elongation over 200%, by mixing a fine conductive fiber having a diameter of not more than  $1\mu\text{m}$  to the conductive polymer, the conductive fiber is oriented at the molding time and the conductivity can be maintained.

There will be listed up, as such conductive fiber, a



teared carbon fiber made from polyacrylonitrile based fiber or carbon coated or silver plated ceramics whiskers made from such as zinc oxide or potassium titanate. However, it is desired to use a flexible one, and there will be listed up silver plated synthetic fiber such as acrylic fiber, rayon, polyester fiber, phenol fiber or like, or listed up single-wall nano-tube or multi-wall nano-tube, and the nano-tube is a conductive fiber having a diameter of not more than  $0.2 \mu\text{m}$ , thus being convenient. Although compounding amount is determined in accordance with a predetermined resistance value, it is in a range of 0.1 to 20 % by weight, and it is of course natural that the transparency is better as the diameter is finer or compounding amount is smaller.

The conductive polymer is obtained by polymerization in which a precursor monomer is polymerized by using an oxidizing agent or catalyst, heat treatment of an intermediate product composed of a non-conjugated polymer, or an electrolytic polymerization in which aromatic compound is polymerized through electro-chemical oxidization or reduction as monomer. The method is not however limited to one of these methods.

It may be possible to form, on the transparent insulating film 9, a low molecule product of conductive polymer through vapor deposition or like, or form the conductive polymer layer through a general printing coating method using emulsion or solution (aqueous or solvent)

containing conductive polymer, so as to have a thickness of about 0.1 to 25  $\mu\text{m}$ . In the case of the conductive polymer, the film thickness and the resistance are often non-ohmic, and even if the film is thickened, there may cause a certain case that a resistance reduction in conformity with this thickness cannot be achieved and light transmittance will be made worse. Because of this reason, it is necessary to preliminarily determine a necessary thickness.

The transparent electrode 10 has its surface resistance of not less than  $10\ \Omega/\square$  and, preferably, not less than  $100\ \Omega/\square$ , and its light transmittance of not more than 90% and, preferably, not more than 80%. The surface resistance value and the light transmittance are in a relation contrary to each other, and hence, in the case of the surface resistance of less than  $10\ \Omega/\square$ , the dopant amount is increased and coloring is made higher, thus obtaining no desired color, hardening the conductive polymer and showing no adequate elongation. Although it is desired for the light transmittance to have a high percentage, in the case of exceeding 90%, the surface resistance is excessively increased and power consumption will be hence increased.

The light emitting layer 13 of the area emitter 4 has an emitting structure which utilizes electricity-light conversion mechanism and illuminates evenly the area of the display section 2, and in consideration of molding material

of resin and its composite structure, there will be listed up an inorganic EL in an organic group, organic EL or LEC (Light Emitting Electrochemical Cell: Electrochemical Light Emitting Element), or like, which may include one directly emitting visible light, or others such as one emitting ultraviolet and converting it to visual light. These ones require opposite electrodes for power supply, and in the first embodiment, one electrode is the transparent electrode 10 and the other one electrode is the base electrode 14.

The inorganic EL is provided with the light emitting layer 13, having thickness of about 5 to 50  $\mu\text{m}$ , between two opposed electrodes, including one transparent electrode and an alternating current of 20 to 100 V and 50 to 400 Hz is applied to thereby emit the same. In the case of the direct current cell such as for cellular phone, it will be necessary to increase voltage and convert into alternating current by an inverter or the like.

The light emitting layer 13 is manufactured in a manner of dispersing powdery inorganic fluorescent material (phosphor), such as zinc sulfide, into an organic material binder of high dielectric substance such as cyanoethyl cellulose, cyanoethyl sucrose, cyanoethyl pulurane or like and dissolving into solution by utilizing acetonitrile, dimethylformamide, dimethylacetamide, or like and working the same with wet-type process. Particularly, for the fluorescent material, multi-coloring process is effected by

doping a metal such as copper, iron or like. Further, it is possible to enhance properties, such as moisture-proof property or adhesiveness to a base member, by encapsulating the fluorescent material with microcapsule by using ceramic through plasma polymerization, sol-gel process or other existing method. In addition, field efficiency may be increased by means of excitation reflector layer formed by further combining, to such binder, a high dielectric material such as barium titanate or potassium titanate.

In order to bond the light emitting layer 13, in good state, to the transparent electrode 10 formed of a conductive polymer having low bonding performance, it is desired to use a material substantially equivalent to that of the anchor coat mentioned hereinbefore.

The light emitting layer 13 can be formed from an ink comprising a fluorescent material powder obtained through doping of copper to zinc sulfide, a high dielectric substance binder such as cyanoethyl cellulose, cyanoethyl sucrose, cyanoethyl pulurene or like, a high dielectric ceramic powder such as barium titanate and a polar solvent such as acetonitrile or can be formed from a solution comprising a hole transferable binder such as polyvinylcarbazole, an electron transferable color such as trishydroxyquinolinola aluminium complex and toluene.

The inorganic EL sheet is conventionally utilized as a flat-shape light source, and in the present invention, it is

adopted only for the display section 2, so that the area of the flat light source to be utilized can be reduced to about 1/5 to 1/100 in comparison with the conventional one utilized as a back light, thus reducing the power consumption.

The organic EL includes low molecular type and high molecular type according to light emission material to be used. The high molecular type therein having a thick film is easily workable, and therefore, in the present invention, the explanation is limited to this type, in which the light emitting layer 13 is clamped and supported between the opposed two electrodes including at least one of transparent electrode. There are provided the light emitting layer having thickness of about 0.1 to 0.15  $\mu\text{m}$  and, as occasion demands, electron injection layer, hole injection layer, carrier layer or like functional layer, and direct current voltage of 5 to 20 V is applied. As the light emitting layer 13, there will be listed up soluble  $\pi$ -conjugated polymer such as: polyparaphenylene vinylene derivative material, polythiophene derivative material, polydialkylfluorene, polyparaphenylene derivative material, polyacetylene derivative material, polyvinylcarbazole derivative material or like (published by CMC company "Organic EL Material and Display"). These solutions are applied through spin-coat, ink-jet printing process or like process. The color is determined by energy gap possessed by respective materials,

and as the energy gap is larger, the color will become a short-wavelength side. The light emitting layer 13 and the upper and lower electrode layers are designed in consideration of the balance of the electron injection and the hole injection. The high molecular type includes a color dispersion type which has a simple structure. This structure is formed of clamping a layer between the electrodes, comprising a polymer such as polyvinyl carbazole or polyphenylene vinylene, quinolino, an electron transfer component of such as trishydroxyquinolino aluminium complex or a positive hole transfer component such as oxadiazole derivative or like, a coumarin derivative as dopant, and laser color such as quinacridone, rubrene or like. As another material, polymethylphenylsilane of  $\sigma$ -conjugated polymer has an emission peak at near-ultraviolet and it is made as visual emission by mixing the laser color such as butylebenzooxazolilthiophene, benzopyranone derivative or like.

The LEC has a structure in which only the light emitting layer 13 is clamped between the opposed two electrodes having at least one transparent electrode and has a thickness of about 15  $\mu\text{m}$ , and the light emitting layer 13 is comprised of, like the organic EL, a conjugated polymer, polymer or oligomer of electrolytic substance having such as ethylene oxide or phosphazene, and metal salt such as lithium trifluoromethanesulfonate. When a direct current voltage of

3 to 5 V is applied, cation or anion of salt electrochemically dopes a conjugated polymer and produces P-type or N-type semiconductors in good electrochemical balance, and provides electrons or holes to the conjugated polymer with high efficiency, thus being emitted as like as organic EL (W096/00968).

In the above three types of area emitters 4, the inorganic EL is preferred because the film thickness can be easily controlled and the inorganic EL has a resistance to environment, and the LEC is also preferred because of its simple structure and no limit in use of electrode material, so that the film thickness can be easily controlled and power consumption can also be reduced.

The base electrode 14 opposing to the transparent electrode 10 is formed from metal or alloy of such as gold, silver, copper, nickel, aluminium, magnesium, calcium, lithium, palladium, platinum or like; conductive ceramic of such as tungsten carbide, silicone carbide, tin oxide or indium oxide, or fullerene, which is subjected to photopolymerization, electron irradiation polymerization, plasma polymerization, electrolyte polymerization or like. In the case of the light emitting layer 13 of an organic EL, a material having a large difference in working function between the material and that of the transparent electrode 10 is selected. In addition, the base electrode 14 will be formed from a conductive ink obtained by mixing fine

particles of these materials or conductive filler such as carbon black, graphite or like in an insulating resin solution of epoxy resin, urethane resin, silicone resin or like.

As like as the transparent electrode 10, in order to suppress the resistance change due to the elongation, it will be desired to mix the fine particles of the conductive ceramics mentioned above or conductive filler such as carbon black or graphite with an organic polymer such as low cross linking density thermosetting resin made from such as epoxy resin, urethane resin, silicone resin or like, or thermoplastic resin having a large molecular weight such as unvulcanized synthetic rubber, thermoplastic elastomer or like or such polymers or polyamide, polyester, polyacryl or chlorinated polyolefine. Further, this base electrode 14 may be formed, in place of the organic polymer, from conductive polymer as mentioned hereinbefore.

In the use of the conductive polymer, the binder is itself made conductive, so that the conductivity can be maintained even if the chain of the conductive filler is broken, thus being further preferred. In addition, in the case of the use of conductive fiber or carbon nano tube having flexibility, resistance can be reduced due to by-pass effect, and the conductivity can be maintained, thus being preferred.

Hereunder, a method of manufacturing the push button



switch member according to the first embodiment mentioned above will be explained.

The belt-shaped transparent electrode 10, having a width substantially equal to a width of the top surface portion of the key-top portion 3, is formed at a portion at which the key-top portion 3 of the transparent insulating film is in a state that the transparent insulating film is disposed at the lowest position. A negative printing using an opaque coloring ink having light shielding property and insulating property is then performed, from the upper portion of the transparent electrode 10, with the position corresponding to the top surface portion of the key-top portion 3 being the center thereof. According to such operation, the opaque color layer 11 having an area sufficient for covering the outer peripheral surface, except the rear surface portion, of the key-top portion 3. In such operation, the punched-out portion 12 contouring the shape of the pattern portion of the display section 2 displaying the switching function is formed at the portion at which the top surface portion of the key-top portion 3 of the opaque color layer 11 is positioned.

Next, on the opaque color layer 11, there is formed the light emitting layer 13 by printing the emitter material in a size slightly smaller than that of the size of the top surface portion of the key-top portion 3 including the punched-out portion 12. According to this operation, the

light emitting layer 13 is embedded in the punched-out portion 12. Furthermore, on the light emitting layer 13, there is formed the base electrode 14 having substantially the same size as that of the light emitting layer 13 so that the light emitting layer 13 stays in the punched-out portion 12 of the opaque color layer 11 to thereby complete manufacturing the printed sheet (not shown) before the drawing process.

There will be listed up, as the emitter material of the light emitting layer 13. One of the examples of the emitting material is an ink comprising a fluorescent material powder obtained through doping of copper to zinc sulfide, a high dielectric substance binder such as cyanoethyl cellulose, cyanoethyl sucrose, cyanoethyl purulene or like, a high dielectric ceramic powder such as barium titanate, and a polar solvent such as acetonitrile into which such ingredients are mixed, or, a toluene solution comprising a hole transferable binder such as polyvinylcarbazole, an electron transferable color such as trishydroxyquinolinola aluminium complex, and toluene into which such ingredients are mixed.

The formation of the pattern portion and the base portion of the display section 2 and the formation of the opaque color layer 11 will be performed by utilizing a generally known method of screen printing using usual transparent or opaque ink, ink-jet printing, thermal

transfer printing, gravure printing, spray coating, dip coating, spin coating, vapor deposition or like method. Further, in some case, a color of the printed base may be utilized as it is.

Next, the printed sheet before the drawing process mentioned above is subjected to the drawing process in conformity with the shape of the desired key-top portion 3 through pneumatic/vacuum molding or press molding process, and then, a shaped sheet having a recess to which the key-top body 16 is provided, is formed. At this time, in order not to largely vary the resistances of the transparent electrode 10 and the base electrode 14, it is necessary for a bent portion of the transparent electrode 10 to ensure an adequate roundness.

In the next process, thermosetting resin is poured into the recess of the shaped sheet formed through the drawing process and then hardened in a mold. Thereafter, a conductive ink is coated to the front end portion of the pressing projection 8 of the key-top portion 3 to thereby form the movable contact point 7, thus completing the push-button switch member according to the first embodiment 1.

The formation of the base, the color layer and the light emitting layer 13 is performed by means of usual screen printing, ink-jet printing, thermo-transfer printing, gravure printing, tampon printing, spraying coating, dip coating, spin coating, vapor deposition or like.

The transparent color layer 15 and the opaque color layer 11 are prepared by mixing dye or pigment with a binder of such as soft resin or elastomer. These layers are tightly contacted to the transparent insulating film 9 and it is desired to have the same elongation property and to be formed of the same resin material. Further, although it is also desired to have a thickness of 1 to 20  $\mu\text{m}$ , it is more preferred to have a thickness of more than 3  $\mu\text{m}$  so as to be easily printed and less than 10  $\mu\text{m}$  because the layer thinner in thickness is suitable to be molded.

The shaping to the key-top portion 3 is generally performed through blow-molding, vacuum-molding, mold-molding process or like process, which is usually utilized. In order to prevent misalignment of design on the display section 2, the mold-molding (molding using mold) will be preferred. In this process, the transparent insulating film 9 is heated to a thermally deformable temperature to a portion except the portion including the display section 2 and, after maintaining the shape in conformity with the mold, a desired shape thereof will be obtained through the cooling before the pressure reduction. As possible as the expansion speed being fast, the resistance of the conductive material will easily increase, and hence, it is preferred that the speed is less than 100 mm/min. or, more preferably, less than 50 mm/min.

A material filling the key-top body 16 forming a

plunger portion or like is selected from hard or soft resin, or elastomer. Although it is not limited for this material to have thermoplastic property or thermosetting property, or having a pellet shape or liquid state, liquid state thermosetting resin will be desired for use because it is easily poured. The formation thereof will be performed by using injection mold, transfer mold, potting or like method, and it is also possible to bond one which has been preliminarily molded.

Next, respective patterns of the display section 2 will be explained.

The display section 2 is composed of a pattern portion consisting of letter, symbol or figure and its base portion, at least one of which is self-emissive, and the self-emitting portion has paired portions one of which is composed of the light emitting layer 13 clamped between the transparent electrode 10 and the base electrode 14.

The letter, symbol or figure constituting the pattern portion of the display section 2 is formed by a usual printing method, and in relation to background of the display section 2, various designs will be devised in combination of transparent light, self-luminous light, reflection light and coloring difference.

Figs. 2 to 11 are sectional views showing display sections having different designs, in which Figs. 2 to 8 show patterns of the display sections of which the letters,

symbols or figures emit light and Figs. 8 and 10 show patterns of the display sections of which the base portions emit light.

The first example of the display section 2 shown in Fig. 2 has a laminated structures, from the upper side, in order of, the transparent insulating film 9, the transparent electrode 10, the opaque color layer 11 including the punched-out portion 12, the light emitting layer 13 embedding the punched-out portion 12 and the base electrode 14, which is the same structure as that of the first embodiment of Fig. 1.

The second example of the display section 2 shown in Fig. 3 has a laminated structures, from the upper side, in order of, the transparent insulating film 9, the opaque color layer 11 constituting the base portion including the punched-out portion 12, a coloring transparent layer 15 constituting a pattern portion embedding the punched-out portion 12, the transparent electrode 10, the light emitting layer 13 and the base electrode 14.

The third example of the display section 2 shown in Fig. 4 has a laminated structures, from the upper side, in order of, the transparent insulating film 9, the opaque color layer 11 constituting the base portion including the punched-out portion 12, a coloring transparent electrode 10a constituting a pattern portion to be inserted to the punched-out portion 12, the light emitting layer 13

embedding the punched-out portion 12 through the coloring transparent electrode 10a, and the base electrode 14.

The fourth example of the display section 2 shown in Fig. 5 has a laminated structures, from the upper side, in order of, the transparent insulation film 9, the transparent electrode 10, the opaque color layer 11 constituting the base portion including the punched-out portion 12, the transparent color layer 15 constituting the pattern portion embedding the punched-out portion 12, the light emitting layer 13 and the base electrode 14.

The fifth example of the display section 2 shown in Fig. 6 has a laminated structures, from the upper side, in order of, a transparent over-coat layer 16, the opaque color layer 11 constituting the base portion including the punched-out portion 12 (in which the punched-out portion 12 is embedded with the over-coat layer 16), the transparent color layer 15 constituting the pattern portion, the transparent insulating film 9, the transparent electrode 10, the light emitting layer 13 and the base electrode 14.

The sixth example of the display section 2 shown in Fig. 7 has a laminated structures, from the upper side, in order of, the transparent insulating film 9, the transparent electrode 10, the opaque color layer 11 constituting the pattern portion, the transparent color layer 15 constituting the base portion, the light emitting layer 13 and the base electrode 14.

The seventh example of the display section 2 shown in Fig. 8 has a laminated structures, from the upper side, in order of, the transparent insulating film 9, the transparent electrode 10, the light emitting layer 13 constituting the pattern portion, a coloring dielectric layer 18a and the base electrode 14.

The eighth example of the display section 2 shown in Fig. 9 has a laminated structures, from the upper side, in order of, the transparent insulating film 9, the transparent electrode 10, the opaque color layer 11 constituting the pattern portion, the transparent color layer 15 constituting the base portion covering the outer periphery of the opaque color layer 11, the light emitting layer 13 and the base electrode 14.

The ninth example of the display section 2 shown in Fig. 10 has a laminated structures, from the upper side, in order of, the transparent insulating film 9, the opaque color layer 11 constituting the pattern portion, the transparent color layer 15 constituting the base portion, the transparent electrode 10 covering the outer periphery of the opaque color layer 11 and the transparent color layer 15, the light emitting layer 13 and the base electrode 14.

The tenth example of the display section 2 shown in Fig. 11 has a laminated structures, from the upper side, in order of the transparent insulating film 9, the opaque color layer 11 constituting the pattern portion, the transparent



color electrode 10a covering the outer periphery of the opaque color layer 11, the light emitting layer 13 and the base electrode 14.

In the examples shown in Figs. 4 and 11 of these examples, the transparent color electrode 10a is formed by coloring the transparent electrode 10, and in such examples, since the transparent color layer 15 is not necessary to be disposed, the manufacturing process can be simplified, thus reducing manufacturing cost.

Furthermore, in the example shown in Fig. 8, since the letter, symbol or figure is formed from the light emitting layer 13, it is not necessary for the opaque color layer 11 to be printed, thus reducing the number of printing steps and, hence, simplifying the manufacturing process.

Further, the transparent color layer 15 and the opaque color layer 11 are formed by mixing dye or pigment with soft resin or elastomer as a binder and it is desired to be disposed closely in contact to the transparent insulating film 9 as like as having the elongating property and is preferred to be formed from resin as like as the transparent insulating film 9.

#### [Second Embodiment of The Invention]

The push-button switch member of this embodiment has substantially the same structure as that of the first embodiment except that a conductive member connected to the transparent electrode and the base electrode is located. A

structure near the top surface portion of the key-top portion according to this embodiment will be explained hereunder with reference to Fig. 12 which substantially corresponds to the details of Fig. 3.

The opaque color layer 11 as a shielding layer and the transparent color layer 15 as the display section 2 are disposed below the transparent insulating film 9. An anchor coat layer 17 is formed under the transparent insulating layer 15 to enhance adhesion performance of the transparent electrode 10. This anchor coat layer 17 may be eliminated if the transparent color layer 15 has the same function as that of the anchor coat layer 17. It is not necessary to make the transparent electrode 10 large and, in order to keep the insulated state from the base electrode 14, it is required for the transparent electrode 10 not to be overlapped with a conductor member 14d continuous to the base electrode 14. For the light emitting layer 13 and the dielectric layer 18b, it is necessary to be formed to cover the transparent electrode 10 at a portion at which the transparent electrode 10 and the base electrode 14 are overlapped for the purpose of maintaining the insulating performance of the base electrode 14 and the transparent electrode 10. The base electrode 14 is covered by an insulating thin film 19. Accordingly, the insulated state between the base electrode 14 and the transparent electrode 10 can be kept, and at the elongated formation of the base electrode 14, the flow of

material of the conductor member 14d of the base electrode 14, which is now softened and flowed, can be restricted, to thereby suppress the increasing of resistance of the base electrode 14.

The field efficiency of the dielectric layer 18b may be increased by adding a high dielectric substance such as barium titanate, potassium titanate or like to the binder of the dielectric layer 18b. In order to establish the insulation between the base electrode 14 and the transparent electrode 10, volume resistance and film thickness of the dielectric layer 18b are important factors, and it is necessary for the dielectric layer 18b to have the volume resistance of more than  $10^{13}$  under application of D.C. 100V and the thickness of at least not less than 10  $\mu\text{m}$ . If this insulating performance is lowered, lightening luminance is lowered and the field efficiency is deteriorated. Thus, attention is to be paid. Of course, the formation of pin hole or mixing of foreign material are to be prevented. In the use of high density ink such as ink including no solvent, a thickened film can be formed at once and the formation of the pin holes due to volatilization of the solvent can be reduced, and the insulating performance can be easily maintained.

A storage modulus of elasticity (elastic modulus) of the binder at the molding temperature is not less than that of the base member and the insulating thin film 19 and,

hence, it is necessary for the binder to take a fluidized state at an earlier time and to be easily elongated. In a dynamic visco-elasticity measurement, it is desired for the storage modulus to be not more than single figure, and more preferably, not more than double figures. In a case where a specimen does not have a size sufficiently larger for the measurement of the dynamic visco-elasticity, a micro-hardness tester will be utilized for distinguishing largeness of storage modulus in a state of maintaining a necessary temperature of the specimen.

The top surface portion of the key-top portion 3 is not distorted and hardly elongated at the time of molding. However, a portion of the key-top side surface is maximally elongated at the time of molding. Therefore, the existence of interface between each material near the top surface portion should be avoided because the damage or breaking tend to occur at the overlapped portion if the transparent electrode 10 or the conductive member 10d continuous thereto and the base electrode 14 or the conductive member 14d continuous thereto are overlapped near the top surface portion.

Furthermore, in order to avoid an accidental breakage or increase of the resistance due to uneven molding, it is very preferred for the stability of the light emission to connect a plurality of switch circuit, as redundant circuit, to the transparent electrode 10 and the base electrode 14,

respectively.

Fig. 13 is a plan view illustrating one example of a pattern of an arrangement of a plurality of base electrodes and the conductor members continuous thereto to be utilized for the member of the push-button switch according to the second embodiment of the present invention.

Each of the base electrodes 14 corresponding to the display sections 2 of a plurality of key-top portions 3 has approximately circular or elliptical shape having an area sufficient for entirely covering the bottom surface side of the light emitting layer 13, and two belt-shaped conductive members 14d extend from the outer peripheral portion of each of the base electrodes 14, which are collected into one main conductive member 14s through path lines 14k and, finally, the main conductive member 14s is connected to the electrode terminal of the push-button switch member 1.

Fig. 14 is a plan view illustrating one example of a pattern of an arrangement of a plurality of transparent electrodes and the conductive members continuous thereto to be utilized for the member of the push-button switch according to the second embodiment of the present invention.

Each of the transparent electrodes 10 corresponding to the display sections 2 of a plurality of key-top portions 3 has approximately circular or elliptical shape having an area sufficient for entirely covering the top surface side of the light emitting layer 13, and two belt-shaped

conductive members 10d extending from the outer peripheral portion of each of the transparent electrodes 10, which are collected into one main conductive member 10s through path lines 10k and, finally, the main conductor member 10s is connected to the electrode terminal of the push-button switch member 1.

Fig. 14 illustrates a case in which an outer shape of the transparent electrode 10 is one size larger than that of the base electrode 14, and Fig. 15 shows a case in which the pattern of the base electrode 14 is overlapped with the pattern of the transparent electrode 10. That is, although the base electrode 14 is covered by the transparent electrode 10 (in a completed product, the light emitting layer 13 is interposed therebetween), these electrodes 14 and 10 are arranged such that the conductive members 14d extending from the base electrodes 14 and the conductive members 10d extending from the transparent electrodes 10 are not overlapped with each other and the path lines 14k and the main conductive member 14s of the base electrodes 14 and the path lines 10k and the main conductive member 10s of the transparent electrodes 10 are not overlapped with each other.

Accordingly, there is no fear of contacting of the conductive members 14d connected to the base electrode 14 to the conductive member 10d of the transparent electrodes 10, and they can be prevented from being damaged or broken, thus ensuring the stable back-lightening.

Fig. 16 is an enlarged sectional view concretely showing a structure of the base electrode 14 in design of the display section substantially similar to that shown in Fig. 12.

As shown in Fig. 16, the base electrode 14 is formed from a composite conductive layer composed of a conductive polymer layer 20 and a conductive filler layer 21 having an organic polymer and a conductive filler. In this structure, even if the chain of the conductive filler is broken, the conductivity can be maintained by additionally disposing the conductive polymer layer 20, thus being further preferred.

Concerning the thickness of the base electrode 14 and the conductive member 14d extending therefrom, it is desirable to have a thin film thickness, after the molding, of more than three times, and more preferably, of more than five times, the dimension of the conductive filler. According to the flowing and deformation of the binder, it is also necessary for the conductive filler to be movable, and it will be desired for it to have a spherical particle shape or like.

In order to ensure the particle chain, fiber-like filler or flat plate-like filler may be further selected, in which the fiber-like filler is orientated in accordance with the flow and hence easily maintains resistance, thus being quite convenient. It is desired for the fiber-like conductive filler to have an aspect ratio of more than 10,

preferably, more than 20 and more preferably, more than 50 and to have a length of less than 0.1 mm in the view point of printing performance. There will be listed up, as such fiber-like filler, one formed by tearing carbon fiber of polyacrylnitorile group, or one formed by effecting carbon coat or silver plating to ceramics whisker of such as zinc oxide or potassium titanate. In these materials, soft one is desirable, and there will be listed up one formed by effecting silver plating to synthetic fiber such as acryl, rayon, polyester, phenol or like, or single-wall nano-tube or multi-wall nano-tube, in which the nano-tube is a conductive fiber having a diameter of less than 0.2  $\mu$ m, being very convenient. The compounding amount is determined on the basis of a desired resistance, which is of 0.1 to 20 % by weight.

[Third Embodiment of The Invention]

Fig. 17 represents a push-button switch member according to the third embodiment of the present invention.

The push-button switch member 1 of the third embodiment of the present invention shown in Fig. 17 is provided with the display section 2, displaying letter, symbol or figure, arranged at the intermediate portion of the key-top portion 3 and adopts the area emitter 4 of self-emitting type.

The push-button switch member 1 according to the third embodiment 3 comprises a contact point sheet 23 and a key-



top portion 3 formed integrally therewith. The contact point sheet 23 has an elastically deformable dome portion 22 having an inner surface to which a movable contact point 7 is arranged at a portion corresponding to a stationary contact point 6 formed on the circuit board 5 in positional conformity therewith, and the key-top portion 3 is provided with a push projection 8 formed to the rear surface of the key-top portion 3 so as to press the central portion of the dome portion 22 of the contact point sheet 23.

On the surface of the transparent insulating film 9, there is integrally provided a first resin mold product 24 having a desired key-top shape and the transparent electrode 10 is disposed to the rear surface side of the transparent insulating film 9.

On the rear surface of the transparent electrode 10, there is formed a transparent color layer 15 having a portion corresponding to the top surface portion of the key-top portion 3 to which the pattern of the display section 2 is formed with a transparent coloring ink. The display section 2 is formed at one portion of the top surface of the key-top portion 3, and the light emitting layer 13 composed of a light emitting substance is disposed to the rear surface of the transparent color layer 15 and the rear surface of the transparent electrode 10 surrounding the transparent color layer 15. Furthermore, the base electrode 14 composed of silver paste is formed to the rear surface of

the light emitting layer 13. A second resin mold product 25, which is provided with the press projection 8 at a portion corresponding to the central portion of the rear surface of the key-top portion 3, is integrally formed to the rear surface of the base electrode 14.

Further, it is to be noted that the substance of the respective elements or portions of the third embodiment are substantially the same as those of the first embodiment.

Hereunder, a manufacturing method of the push-button switch member 1 according to this third embodiment will be described.

First, the belt-shaped transparent electrode 10, having a width substantially equal to a width of the top surface portion of the key-top portion 3, is formed at a portion at which the key-top portion 3 of the rear surface of the transparent insulating film 9 is positioned, and the pattern portion of the display section 2 is formed with the transparent coloring ink on the transparent electrode 10. Then, the light emitting layer 13 is formed by coating the emitting substance on the transparent electrode 10 and the display section 2 on the rear surface side of the key-top portion 3. Next, the opaque color layer 11 is formed by coating the light shielding and insulating ink on the outer peripheral portion of the light emitting layer 13 and on the transparent electrode 10 except the portion corresponding to the rear surface central portion of the key-top portion 3.

The base electrode 14, as an opposing electrode, is printed on the light emitting layer 13 so as to be within a printing area of the opaque color layer 11. The second resin mold product 25 is formed on the base electrode 14 and the push projection 8 is also formed integrally to the rear surface central portion thereof.

In the next step, the first resin mold product 24, which is preliminarily formed so as to provide a desired key-top shape, is bonded and fixed to the front surface side of a position corresponding to the transparent insulating film 9, to which the second resin mold product 25 is formed, to thereby complete the push-button switch member 1 of this third embodiment.

In the third embodiment, the light emitting layer 13 is disposed between the first resin mold product 24 and the second resin mold product 25 at an intermediate position of the key-top portion 3. Accordingly, since the light emitting layer 13 is disposed in an environmental condition isolated from an external atmosphere, there is less influence by water or oxygen, and hence, the luminescence cannot be deteriorated even in a long term use.

Further, in the embodiments 1 and 2, the display section 2 is positioned to the top surface portion of the key-top portion 3 and, on the other hand, in the embodiment 3, it is positioned to the intermediate position of the key-top portion 3. However, the locating position of the display

section 2 is not limited as far as it is integrally formed with the top surface portion, the rear surface portion or the intermediate portion of the key-top portion 3, and it will be decided in accordance with desirable design.

Furthermore, in general, the display section 2 is positioned to an upper position of the key-top portion 3 because the transparent electrode 10 is positioned above the transparent insulating film 9. However, as the light emitting layer 13 is influenced in its usable life period by water or oxygen, the invasion of the water or oxygen from the upper or lower portion is made evenly by integrally molding, by bonding agent or with an inmold, a mold product composed of the transparent insulating resin on the transparent insulating film 9, to which the display section 2 has been printed and coated, after the molding thereof and forming the display section 2 at the central portion of the key-top portion 3, which is an effective countermeasure for the long time use.

In the case where the inorganic EL sheet is used as a conventional flat light source, it needs a wide area, and in the push-button switch member according to the present invention, the light emitting layer is provided only for the display section of the key-top portion, so that the necessary area is made smaller than that in the conventional inorganic EL sheet to a size of about 1/5 to 1/100 of the conventional one, thus remarkably reducing the power

consumption proportionally.

[Examples]

Examples 1 to 5 prepared for evaluation of the embodiments 1 to 3 mentioned above and Comparative Examples 1 and 2 prepared in comparison with the Examples 1 to 5 will be explained hereunder.

[Preliminary Test]

Hereunder, preliminary test will be explained, which was carried out to confirm the performance of a printed sheet before molding of the push-button switch member 1 according to the present invention.

(Preparation of Thermoplastic Binder)

Thermoplastic polyesters (Manufactured by TOYO-BO, Commercial Name: Byron) having storage modulus, at 100°C, of  $1 \times 10^6$  (Pa) and  $5 \times 10^8$  (Pa) were dissolved into Cellosolve acetate so as to have solid content of 50wt%, respectively, to thereby prepare insulating binder solutions, (the former being denominated as IL and the latter being denominated as IH).

(Preparation of Silver Paste)

Silver pastes were prepared by mixing, with the IL, desired amounts of particular silver powder of average particle diameter of  $2.5 \mu\text{m}$  and  $0.3 \mu\text{m}$  (Manufactured by FUKUDA KINZOKU-HAKUFUN KOGYO K.K., Commercial Name: Silcoat; and Manufactured by D.M.C. Square, Commercial Name; Silver Powder) so as to provide a volume resistance of  $1 \times 10^{-3}$  to

5 x 10E-2 (denominated as ILSL and ILSS, respectively). With respect to the IH, in the same manner, the silver pastes IHSL and IHSS were obtained.

(Tension Testing)

Ten kinds of test specimens were prepared by using the four kinds of silver pastes prepared by the above manner and these silver pastes were printed on amorphous polyethylene terephthalate sheets each having a thickness of 50  $\mu$ m and then dried. Thereafter, insulating binder solution was further coated to cover the same with a film having a thickness of 10  $\mu$ m. The thus obtained printed materials were punched out each in shape of dumbbell having a neck width of 2 mm, and in an atmosphere of 100 °C, tension testing was performed at pulling speed of 100mm/min. and resistance and elongation were measured at 200% elongation optionally. After the testing, film thicknesses of the silver pastes on the test piece were measured.

Test results with respect to these ten kinds of specimens are shown in the following Tables 1 and 2.

Table 1

Specimen No.	1	2	3	4	5
Kind of Silver Paste	ILSS	ILSL	IHSS	IHSL	ILSS
Initial Film Thickness( $\mu\text{m}$ )	10	25	10	25	10
Film Thickness after Elongation( $\mu\text{m}$ )	3	9	3	9	3
Kind of Coat Material	IH	IH	IL	IL	Non
Initial Resistance( $R_0$ )( $\Omega$ )	2.3	0.7	2.3	0.8	2.1
Resistance after Elongation( $R$ )( $\Omega$ )	193	72	252	161	4225
$R/R_0$	84	103	110	201	2012

Table 2

Specimen No.	6	7	8	9	10
Kind of Silver Paste	IHSL	ILSS	ILSL	ILSS	ILSL
Initial Film Thickness( $\mu\text{m}$ )	25	2	10	5	10
Film Thickness after Elongation( $\mu\text{m}$ )	9	0.8	3	2	3
Kind of Coat Material	Non	IH	IH	Non	Non
Initial Resistance( $R_0$ )( $\Omega$ )	0.7	5.7	2.1	5.5	2.1
Resistance after Elongation( $R$ )( $\Omega$ )	2621	349142	930027	Over	Over
$R/R_0$	3744	61253	44287	$\infty$	$\infty$

According to these test results, the specimens 5 and 6 having no insulation coat showed a large increase in resistance after the tension testing in comparison with the case having the insulation coat. In addition, the specimens 7 and 8 having film thickness, after the tension testing, of less than three times the size of the conductive particle

showed remarkable increase in resistance.

[Example 1]

This Example 1 corresponds to the embodiment 1 of the present invention.

First, a transparent treating solution was obtained by dispersing multi-wall nano-tube (wire diameter of  $0.01\ \mu\text{m}$ , average wire length of  $5\ \mu\text{m}$ , manufactured by Hyperion Catalysis International) of 3% with respect to solid component of a solution of poly (3,4-ethylene dioxythiophen) (Denatron 4001, manufactured by NAGASE SANGYOU K.K.) obtained by doping sulfonated polystyrene by using a homogenizer into the foregoing solution. Next, the treating solution was coated on the entire surface of the one surface of the transparent insulating film 9 (polymethyl methacrylate (Acryplen, manufactured by MITSUBISHI Rayon) having thickness of  $100\ \mu\text{m}$ ) by using a gravure coater to thereby form the transparent electrode 10 having a thickness of  $1\ \mu\text{m}$ , which has full light transmittance of 70% (measured in accordance with JIS-K7105) and surface resistance of  $500\ \Omega/\square$  (measured in accordance with JIS-K6911).

The opaque color layer 11 was coated with a black color ink having shielding performance and insulating performance, and the base portion of the display section 2 was coated entirely through the screen printing except for the pattern portion of the display section 2 and the second electrode terminal portion. The light emitting layer 13



having thickness of 20  $\mu$ m was formed to the punched-out portion 12 of the base portion by printing the inorganic EL paste prepared by dispersing zinc sulfide having green luminescent color into cyanoethylcellulose, and the exciting reflection layer, which has barium titanate powder dispersed in cyanoethylcellulose, having thickness of 10  $\mu$ m was formed. Finally, the opposing electrode was disposed on the light emitting layer 13 and the terminal electrode connected thereto was disposed to the opaque color layer 11 by means of base electrode 14 (Dohdent NH-030A, Thermoplastic polyamide binder, manufactured by NIHON HANDA K.K.). After the printing process, it was adequately dried by a vacuum dryer to thereby obtain a printed film.

By using a mold having twelve cavities each having a diameter of 12 mm, a depth of 7.8 mm and a bottom surface of R50 (mm) and a first male mold framed thereby and formed from an elastic material having hardness of 90° (shore A), a metal piece having a diameter of 8 mm was placed, for heat insulation, at the pattern portion of the display section 2, then heated to 110°C by utilizing infrared ray, and the metal piece was removed. Immediately thereafter, the printed film was subjected to cold compression molding. After the removal of the male mold, necessary amount of liquid silicone rubber (hardness of 80° shore A) was poured into a mold as a key-top body 16, and by utilizing a second male mold having a sectional shape shown in Fig. 1, the press projection 8 was

formed to the rear surface portion of the key-top body 16. The movable contact point 7 was formed to this pressing projection 8 by silicone ink containing carbon black, thus obtaining the push-button switch member 1 (corresponding to the first embodiment 1).

The electrode terminal of the push-button switch member 1 and the electrode terminal on the circuit board 5 were rested in a mated state, and alternating current of 50V and 100Hz was applied to the light emitting layer 13. In this moment, all the display sections 2 emitted green color with luminance of 5.2 nit.

[Comparative Example 1]

Comparative Example 1 was prepared for the evaluation of the first embodiment.

The Comparative Example 1 is substantially the same as the Example 1 except that the transparent electrode 10 was formed from ITO ink (Manufactured by SUMITOMO OSAKA Cement K.K.)(no nano-tube) in which transparent ceramics particles were dispersed.

When the push-button switch member according to this Comparative Example 1 was lightened, the switch member was not lightened at five points, and the remaining ones were lightened with uneven luminance and it was difficult to regard the state of lightening.

[Example 2]

This Example 2 corresponds to the first embodiment of

the present invention.

In this Example 2, the transparent electrode 10 was prepared as like as Example 1 by coloring a conductive polymer with red. The light emitting layer 13 was composed of zinc sulfide having white color.

First, a transparent red-color treating solution was obtained by adding multi-wall nano-tube (wire diameter of  $0.01\ \mu\text{m}$ , average wire length of  $5\ \mu\text{m}$ , manufactured by Hyperion Catalysis International) of 3% with respect to solid component of a solution of poly (3,4-ethylene dioxythiophen) (Denatron 4001, manufactured by NAGASE SANGYOU K.K.) obtained by doping sulfonated polystyrene, and dye composed of azo compound of 0.1 wt% with respect to the solid component of the foregoing solution and dispersing it by using a homogenizer into the foregoing solution. Next, the treating solution was coated entirely on the one surface of the transparent insulating film 9 (polymethyl methacrylate (Acrylen, manufactured by MITSUBISHI Rayon) having thickness of  $100\ \mu$ ) by using a gravure coater to thereby form the red color transparent electrode 10 having a thickness of  $1\ \mu\text{m}$ . Furthermore, the non-colored conductive polymer solution mentioned above was coated on the periphery of the pattern section of the display section 2 through the screen printing.

Substantially the same treatment as the one carried out for the Example 1, was effected, thereafter, to thereby

obtain the push-button switch member 1.

The electrode terminal of the push-button switch member 1 and the electrode terminal on the circuit board 5 were rested in a mated state, and alternating current of 50V and 100Hz was applied to the light emitting layer 13. In this moment, all the display sections 2 emitted with luminance of 6.0 nit.

[Example 3]

This Example 3 corresponds to the second embodiment 2 of the present invention.

First, a transparent treating solution was obtained by dispersing multi-wall nano-tube (wire diameter of  $0.01\ \mu\text{m}$ , average wire length of  $5\ \mu\text{m}$ , manufactured by Hyperion Catalysis International) of 3% with respect to solid component of a solution of poly (3,4-ethylene dioxythiophen) (Denatron 4001, manufactured by NAGASE SANGYOU K.K.) obtained by doping sulfonated polystyrene by using a homogenizer into the foregoing solution. Next, the treating solution was coated entirely on one surface of the transparent insulating film 9 (polymethyl methacrylate (Acryplen, manufactured by MITSUBISHI Rayon) having thickness of  $100\ \mu\text{m}$ ) by using a gravure coater to thereby form the transparent electrode 10 having a thickness of  $1\ \mu\text{m}$ , which has full light transmittance of 70% (measured in accordance with JIS-K7105) and surface resistance of  $500\ \Omega/\square$  (measured in accordance with JIS-K6911).

The opaque color layer 11 was coated with a black color ink having shielding performance and insulating performance, and the base portion of the display section 2 was coated entirely through the screen printing except for the display section 2 and the second electrode terminal portion. The light emitting layer 13 having thickness of 20  $\mu\text{m}$  was minimally formed to the opened portion of the base portion by printing the inorganic EL paste prepared by dispersing zinc sulfide having green luminescent color into cyanoethylcellulose, and the dielectric layer 18b which has barium titanate powder dispersed in cyanoethylcellulose, having thickness of 10  $\mu\text{m}$  was formed. Finally, the base electrode 14 was formed on the dielectric layer 18b with silver paste (ILSS) and the terminal electrode composed of the conductive member 14d continuous thereto was formed on the opaque color layer 11. A printing process was then performed so as to cover the base electrode 14 and its conductive member 14d by using the above-mentioned thermoplastic binder (IH). After the printing process, it was adequately dried by a vacuum drier to thereby obtain a printed film.

By using a mold having twelve cavities each having a diameter of 12 mm, a depth of 78 mm and a concave bottom surface of R50 (mm) and a first male mold framed thereby and formed from an elastic material having hardness of 90° (shore A), a metal piece having a diameter of 8 mm was

placed, for heat insulation, to the display section 2, then heated to 110°C by utilizing infrared ray, and the metal piece was removed. Immediately thereafter, the printed film subjected to cold compression molding. After the removal of the male mold, necessary amount of liquid silicone rubber (hardness of 80° shore A) was poured into a mold as a key-top body 16, and by utilizing a second male mold having a sectional shape shown in Fig. 1, the projecting portion was formed to a core portion. A contact point was formed to this projecting portion by silicone ink containing carbon black, thus obtaining the push-button switch member 1 having a plurality of key-top portions 3.

The electrode terminal of the push-button switch member 1 and the electrode terminal on the printed circuit board were rested in a mated state, and alternating current of 50V and 100Hz was applied to the light emitting layer 13. In this moment, all the display sections 2 of the plural key-top portions 3 emitted green color with luminance of 6.2 nit having sufficient brightness.

[Example 4]

This Example 4 corresponds, as like as Example 3, to the second embodiment of the present invention.

In this Example 4, the transparent electrode 10 was prepared as like as Example 3 by coloring a conductive polymer with red. The light emitting layer 13 was composed of zinc sulfide having white color.

First, a transparent red-color treating solution was obtained by adding multi-wall nano-tube (wire diameter of  $0.01\ \mu\text{m}$ , average wire length of  $5\ \mu\text{m}$ , manufactured by Hyperion Catalysis International) of 3% with respect to solid component of a solution of poly (3,4-ethylene dioxythiophen) (Denatron 4001, manufactured by NAGASE SANGYOU K.K.) obtained by doping sulfonated polystyrene and dye composed of azo compound of 0.1 wt% with respect to solid component of the foregoing solution and dispersing it by using a homogenizer into the foregoing solution. Next, the treating solution was coated entirely on the one surface of the transparent insulating film 9 (polymethyl methacrylate (Acryplen, manufactured by MITSUBISHI Rayon) having thickness of  $100\ \mu\text{m}$ ) by using a gravure coater to thereby form the red color transparent electrode 10 having a thickness of  $1\ \mu\text{m}$ . Furthermore, the non-colored conductive polymer solution mentioned above was coated on the periphery of a design pattern through the screen printing. Thereafter, treatment was effected to the dielectric layer 18b as like as in the Example 1. Then, the base electrode 14 was prepared, as like as the transparent electrode 10, with conductive ink which has 20% of multi-wall nano-tube dispersed in the conductive polymer, and silver paste (ILSL) was then printed so as to provide thickness of  $10\ \mu\text{m}$ . Thereafter, as like as Example 2, a push-button switch member 1 having a plurality of key-top portions was obtained.

The electrode terminal of the push-button switch member 1 and the electrode terminal on the printed circuit board were rested in a mated state, and alternating current of 50V and 100Hz was applied to the light emitting layer 13. In this moment, the display sections 2 of the plural key-top portions 3 entirely emitted with luminance of 7.0 nit, providing sufficient brightness.

[Example 5]

This Example 5 corresponds to the third embodiment of the present invention.

In this Example 5, the transparent insulating film 9 was prepared by laminating ethylene-vinyl-alcohol copolymer films having thickness of 15  $\mu$ m to both plasma treated surfaces of a polypropylene film having thickness of 100  $\mu$ m. The base portion of the display section 2, except the pattern portion, was entirely coated with green opaque color ink through screen printing. On the thus coated display section 2, the pattern portion of the display section 2 and the terminal electrode connected thereto were formed through the ink jet printing using a solution having polyaniline and a sulfonated dendorimer dopant (a dopant obtained by reacting benzenesulfonic acid with dendorimer (DAB(PA)8) which is derived from diaminobutane (manufactured by DSM Firm) and cyanoethylene) of 1/6 mol of structural unit of polyaniline. Moreover, conductive polymer ink, obtained by being mixed with silver powder (Silcoat, manufactured by



FUKUDA KINZOKU-HAKUFUN KOGYO K.K.) of 75 wt% solid component of polyaniline solution, was printed as formed layer having thickness of 5  $\mu\text{m}$  so as to cover the polyaniline from the periphery of the pattern portion of the display section 2 to the terminal portion. The transparent electrode 10 provided the full light transmittance of 65% (measured in accordance with JIS-K7105) and surface resistance of 700  $\Omega/\square$  (measured in accordance with JIS-K6911).

The light emitting layer 13 having thickness of 15  $\mu\text{m}$  was then formed so as to cover the transparent electrode 10 through the ink jet printing using ink for LEC having poly (p-phenylene-2, 6-benzoimidazol), polyethylene oxide and lithium toluene-sulfonate. Then, the base electrode 14 of the light emitting layer 13 and the terminal electrode connected thereto were formed, from silver mixed conductive polymer ink, apart from the above-mentioned formed layer. After the printing process, it was adequately dried by a vacuum dryer to thereby obtain a printed film.

By using a female mold having fifteen cavities each having a size of 3 mm x 5 mm and a depth of 1.5 mm of recessed flat bottom surface portion, and a male mold having a size of 2.8 mm x 4.8 mm and a height of 0.9 mm of flat protruded top surface portion, a metal piece having a size of 2.6 mm x 4.6 mm, for heat insulation, was placed on the pattern portion of the display section 2, and was heated at 100°C by utilizing infrared ray, and then, the metal piece

was removed. Immediately thereafter, the printed film was subjected to cold compression molding. After the removal of the male mold, necessary amount of liquid state epoxy resin containing iron component of 10 wt% as oxygen removing agent was poured, and by using the second male mold having the same sectional area as that shown in Fig. 11, the second resin molded form 20 and the push projection 8 on its rear surface central portion were formed.

Furthermore, a first resin molded form 19, having a desired key-top shape, formed from acrylic resin was bonded with two component acrylic adhesive. An electrode portion of the thus obtained molded form was masked and dipped in silanol solution with a catalyst of aminosilanol. Then, it was dried at a temperature of 40°C and reacted to thereby form a silica layer, having thickness of 2  $\mu$ m, on the surface of the molded form, thus obtaining a uniform push-button switch member 1 (corresponding to the second embodiment).

The electrode terminal of the push-button switch member 1 and the electrode terminal on the circuit board 5 were rested in a mated state, and direct current of 4V was applied to the light emitting layer 13. In this moment, the display sections 2 entirely emitted with luminance of 6.5 nit.

[Comparative Example]

The Comparative Example 2 was prepared for the

evaluation of the Example 5.

The Comparative Example 2 was prepared by substantially the same manner as the Example 3 except that the transparent electrode 10 was formed through ion spattering of indium tin oxide.

When the push-button switch member according to the Comparative Example 2 was lightened, it was not lightened at all.

#### Possibility of Industrial Usage

This invention is effectively utilized for a back-light type push-button switch member capable of lightening up a display section even at a dark place in push-button switch members each having a display section displaying a switching function in an input device such as cellular phone (portable phone), portable terminal such as PDA (Personal Digital Assistant), car-stereo, board computer mounted to vehicle, audio-set, measurement instrument, personal computer, etc.